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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in Fuel Injection Systems for Internal Combustion Engines

We, ROBERT BOSCH GMBH, a German Company, of 4, Breitscheidstrasse, Stuttgart-W, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to a fuel injection system for an internal combustion engine, such as an engine operable with mixture compression, which system has at least one solenoid operable injection valve to which the fuel to be injected is fed through a pressure line by means of a pump, such as a pump driven by an electric motor.

The invention is particularly applicable to the fuel supply in an electronically controlled fuel injection system having a plurality of injection valves, and its general object is to preclude the emergence of fuel from one of the injection valves if the latter should remain open contrary to the intended method of operation as a result of a mechanical or electrical fault.

In a known injection system, the fuel is fed by way of a filter to a fuel pump which is driven by an electric motor and delivers the fuel to the solenoid operated injection valves at a pressure of two atmospheres gauge, for example. The pressure is maintained constant by a pressure regulator, and the fuel not injected is returned to the fuel tank. The quantity of fuel injected is determined by the ratio of the open periods of the injection valves to the sum of the open and closed periods.

Normally, this system operates satisfactorily. However, it is conceivable for an injection valve not to be closed after the engine has been switched off. This may be occasioned by a defect in the electrical system whereby one or a plurality of the valves remains permanently under voltage for example. A further possibility is that of impurities in the fuel which result in the mechanical jamming of the jet needle in the injection valve. If, when such a defect occurs, the level of the fuel in the tank is higher than the outlet opening of the open valve a circumstance which may be contingent upon construction or caused by stopping the vehicle on a gradient, it is possible for the static pressure difference to cause fuel to flow from the open valve and enter one of the cylinders of the internal combustion engine. Thus, there is the risk of the affected cylinder being blocked, damaged, or destroyed when the internal combustion engine is re-started. Further, there is the acute risk of fire if the fuel flows out on to parts of the internal combustion engine that are still hot.

In accordance with the invention, a check valve is arranged in the pressure line between the pump and the injection valve or valves.

Advantageously, the check valve is constructed as a spring-loaded disc valve, the spring force advantageously being set so that the valve opens when the pressure difference between its inlet and outlet is more than 0.1 atmospheres. The check valve obviates the possibility of fuel flowing out of an open injection valve as the result of a small static pressure difference.

The invention is further described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a schematic diagram of a petrol injection system having a check valve arranged in the fuel pressure line, and

Fig. 2 illustrates an axial longitudinal section of a preferred embodiment of the check valve, constructed as a non-return valve.

The petrol injection system shown in Fig. 1 is intended for operating a four cylinder four-stroke engine (not illustrated) and comprises four solenoid operable injection valves each screwed into the associated intake manifold immediately upstream of the intake part of one of the cylinders, only one of which injection valves designated 10 is illustrated in the drawing. The fuel to be

injected is taken from a tank 11 by way of a suction line 13 leading to a fuel filter 12, and fed to a pump 14 which is driven by an electric motor. The electric motor only receives current, by way of contacts 15, 16 of a relay 17 from a battery 18, provided for starting the internal combustion engine when, and for as long as, an ignition switch 19 is closed. The fuel delivered by the pump 14 flows to the injection valves 10 by way of a common pressure line 21 and a respective one of four branch lines 22, 23, 24 and 25. The fuel pressure may be read from a pressure gauge 30 and is maintained at a fixed value of two atmospheres gauge pressure by a pressure regulator 31. When the pressure exceeds this desired value, the pressure regulator opens the access to a return flow line 32 and allows the fuel delivered in excess to return to the tank.

Since the pressure of the fuel located upstream of the injection valves is virtually constant, the metering of the fuel entering the intake manifold of the internal combustion engine and there mixing with the intake air at each injection operation can be effected by time control by square-wave electrical pulses 34 fed to the magnetizing coils (not illustrated) of the valves by way of control leads. These pulses are supplied by an electronic control device (not illustrated) and their duration may be varied in dependence upon the prevailing operating parameters of the internal combustion engine, such as engine speed, pressure in the intake manifold, oil temperature, or air temperature. The injection valves open at the commencement of the pulses 34 and close under spring force at the termination thereof.

To preclude the risk of one of the injection valves remaining open for the reasons described initially when the internal combustion engine is switched off, and that, despite the pump 14 being switched off, fuel can flow out of the said valve, a check valve 40 (illustrated in detail in Fig. 2) is arranged in the pressure line 21 downstream of the pump 14 and upstream of the branch lines 22 to 25 leading to the injection valves.

The metal housing 41 of the check valve 40 contains an inlet bore 42 extending substantially to the centre region thereof and at an abutment shoulder 43, merging into an outlet bore 44 which narrows conically in the first instance and then continues in cylindrical shape. A spider 45, injection moulded from petrol-resistant plastics material, contains a central through bore 46 in a collar-shaped mid-portion 47 and has radially projecting ribs 48 which abut resiliently against the shoulder 43. A helical spring 49 is inserted into the mid-portion 47, and its other end is slipped on to a concentric extension 50 of a valve disc 51 also made from plastics material, which spring urges the valve disc against the raised edge 52 (serving as a sealing surface) of a valve insert 53 made from metal and pressed into the inlet bore 42. The initial compression of the spring 49 is so selected that the valve disc 51 is raised and allows fuel to flow to the outlet bore 44 and to the injection valves connected thereto only when the pressure in the inlet exceeds the pressure in the outlet bore 44 by at least 0.1 atmospheres.

A high pressure difference of this nature cannot be attained solely by hydrostatic pressure when the internal combustion engine is not running and the pump 14 is switched off. Thus, a reliable safety arrangement is obtained whereby fuel is prevented from flowing out of an injection valve when the internal combustion engine is not running.

The achieving of the desired action of the check valve requires the pressure regulator to close in a completely tight manner as soon as the pump ceases to deliver, since the fuel located in the return line could otherwise flow into the internal combustion engine. This applies to a particularly high degree when, as frequently occurs in practice, the return line opens into the tank below the level of the liquid, since all or part of the contents of the tank could also then flow out by way of the return line.

The check valve 40 acts as a non-return valve and normally prevents the loss of pressure from the downstream part of the line 21 when the engine is stopped. This facilitates the restarting of the engine as the pump outlet pressure can build up more rapidly to the desired value of two atmospheres.

If a pressure regulator completely tight in the normal state is unrealizable for technical reasons, the internal combustion engine cylinders have to be protected against filling by an additional non-return valve which is arranged between the injection valves and the pressure regulator and allows the fuel to flow only from the branch lines 23 to the pressure regulator 31 but reliably blocks the flow of fuel in the reverse direction. However this non-return valve will not prevent the loss of pressure from the line 21 when the engine is stopped.

WHAT WE CLAIM IS:—

1. A fuel injection system for an internal combustion engine, which system has at least one solenoid operable injection valve, a feed pump for the fuel to be injected, a pressure line connecting the pump outlet to the injection valve or valves, and a check valve arranged in said pressure line between the pump and the injection valve or valves.

2. A fuel injection system as claimed in claim 1, in which the check valve is a spring-loaded valve.

3. A fuel injection system as claimed in

claim 1 or 2, in which the check valve is adapted to open only when the pressure in the inlet of the check valve is greater than the pressure in the outlet by an amount in excess of 0.1 atmospheres.

4. A fuel injection system as claimed in claim1, 2 or 3 in which a pressure regulator is connected to said pressure line downstream of the check valve, said regulator being adapted to discharge from said pressure line fuel delivered by the pump but not injected through the injection valve or valves.

5. A fuel injection system as claimed in claim 4 in which the regulator is adapted to completely close the discharge connection when the pump is not running.

6. A fuel injection system as claimed in claim 4 in which the regulator is not adapted to completely close the discharge connection when the pump is not running and is connected to said pressure line through a non-return valve.

7. A fuel injection system for an internal combustion engine constructed substantially as herein described with reference to and as illustrated in the accompanying drawings.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale